

# THE ECHINOIDS *MICRASTER* AND *EPIASTER* FROM THE TURONIAN AND SENONIAN OF ENGLAND

by ROBERT B. STOKES

ABSTRACT. A revised nomenclature and stratigraphical distribution are recorded for species of the spatangoid genera *Epiaster* and *Micraster* from the Turonian and Senonian of southern England. Distinguishing characters of the species are summarized, and the names *E. michelini*, *E. laxoporus*, *M. normanniae*, *M. decipiens*, *M. coranguinum simpsoni*, and *M. westlakei* advocated for British material. The old *cortestudinarium* Zone is here replaced by a lower *normanniae* Zone, of probable Turonian age, and an upper *decipiens* Zone, of Coniacian date. These new zones are defined in the Dover cliffs, where the base of the *planus* Zone, here redefined on the basis of spatangoid faunas, is held to correspond with the base of the Chalk Rock.

MICRASTERS from southern England need little or no introduction as they form the evidence for three widely-read classic papers (Rowe 1899; Kermack 1954; Nichols 1959) which are summarized in various text-books and review papers. Rowe described in detail many of the evolutionary trends which affect parts of the test and he emphasized their use in stratigraphy. Kermack's biometrical study confirmed and extended Rowe's results, and Nichols interpreted the evolutionary changes in terms of functional morphology by comparison with living spatangoids.

Twentieth-century British authors have mainly followed the nomenclature used by Rowe even though he had been unable to consult the most recent taxonomic revision of *Micraster* made by Lambert in 1895. Kermack (1954, p. 378) pointed out that 'the systematics of the genus *Micraster* are in a very unsatisfactory state'. The author has tried to rectify this situation elsewhere (Stokes 1975) and here gives only diagnoses of the English species, omitting their synonymies and lengthy descriptions of the genus and the evolutionary trends to which it was prone. The systematic notes on *Epiaster* are more detailed than those on *Micraster*.

The stratigraphical ranges of the spatangoids are based on both recent collections and a re-examination of original museum material (see Acknowledgements). Mr. C. J. Wood's specimens from the cliffs between Dover and South Foreland (TR 325415-360433) have been invaluable in this study and enable revisions of certain zonal boundaries to be suggested.

This paper therefore summarizes a revised nomenclature for species of *Epiaster* and *Micraster* from southern England, and indicates their stratigraphical ranges.

## SYSTEMATIC NOTES

The taxonomy of *Epiaster* and *Micraster* and their species is somewhat confused because in the past there has been general adherence to a classification based essentially on the presence or absence of fascioles, and there is an abundance of synonyms.

Species names adopted in the stratigraphic section of this paper are therefore defined below. The signs attached to the synonymy list of *E. michelini* correspond to Richter's system as advocated by Matthews (1973). *Micraster* species are treated alphabetically.

#### EPIASTER d'Orbigny, 1855

*Type species. Epiaster crassissimus* (Defrance), 1827 by the subsequent designation of Lambert (1895).

*Epiaster* has generally been regarded as distinguishable by the absence of all fascioles, whereas *Micraster* possesses a sub-anal fasciole. Whilst the type species *E. crassissimus* lacks fascioles, absence or presence of fascioles can no longer be considered a generic characteristic. The really distinctive features of *Epiaster* are: adults rarely exceed 60 mm in length, and more commonly are in the range 30–50 mm; a very thin test, usually about 0.4 mm thick; a marked sub-anal heel. The term 'heel' is here introduced for raised or attenuated areas of interambulacrum 5 below the periproct, and 'rostrum' is restricted to such projections above the periproct (e.g. as in *Micraster coranguinum rostratus*). At present both these features are called 'rostrum'.

Other characteristics of the genus *Epiaster* include: a broad and shallow anterior notch (less than 1 mm deep at ambitus); peristome far from the anterior border (one-third to one-quarter of the total length) with, at most, a very feebly projecting labrum; peristome surrounded by a smooth rim and well-developed pores in the adjacent ambulacra; all interambulacra join the peristomal margin and are often thickened here to add strength to the delicate peristomal rim; paired petals are deeply sunken and their conjugate pores are all elongate, in some cases more so in the inner than in the outer rows; interporiferous zones of the paired petals are smooth; unpaired petal is broad with divergent edges, its pores are never conjugate; in the ethmophract apical system, none of ocular plates I, IV, and V touches the madreporite (text-fig. 1); periproct is oval, elongated in a vertical sense, and situated high (70–90% of total height—see Stokes 1976, for method) on the outwardly sloping posterior face; plastronal tubercles never tightly packed together; periplastronal areas are broad and finely granular; sub-anal fasciole is narrow when developed and often diffuse in nature, on the oral surface it is situated immediately behind a distinct swelling at the posterior of the plastron.

*Range.* ?Aptian, Albian to Lower Maastrichtian.

#### *Epiaster michelini* (Agassiz), 1847

Plate 107, figs. 4–6, 10, 11; text-fig. 1a, b

\**Micraster Michelini* Agassiz in Agassiz and Desor 1847, p. 23.

*Micraster Michelini* Agassiz; d'Orbigny 1855, p. 205, pl. 866.

*Micraster Michelini* Agassiz; Desor 1858, p. 363, pl. 41, figs. 5–8.

*Micraster Michelini* Agassiz; Cotteau and Triger 1859, p. 244, pl. 39.

?p. *Micraster cor-testudinarium* Goldfuss; Quenstedt 1874, p. 646, pl. 87, fig. 31, 31a.

vp. \**Micraster Sanctae-Maurae* Gauthier, 1886, p. 356. Material from Saint-Maure only.

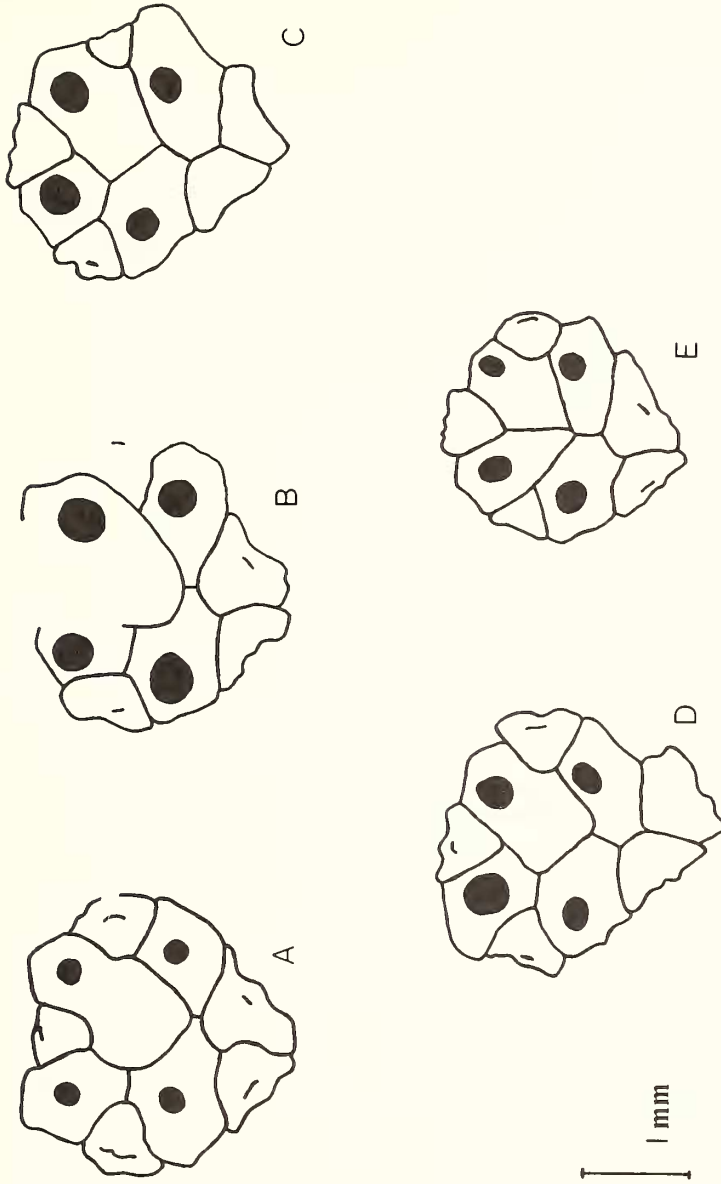
*Micraster Michelini* Agassiz; Lambert 1895, p. 192.

vp. *Micraster corbovis* Forbes; Rowe 1899, p. 518.

vp. *Micraster Leskei* Desmoulins; Rowe 1899, p. 525.

v. \**Micraster leskei* var. *joviniacensis* Lambert in Lambert and Thiéry 1924, p. 481, pl. 12, fig. 10.

?*Micraster micranthus* Lambert in Lambert and Thiéry 1924, p. 481.



TEXT-FIG. 1. Apical systems of *Epiaster* spp. A and B = *E. michelini*; C, D, and E = *E. laxoporus*. A from Cenomanian, Briollay; B from Turonian, Briollay; C, D, and E from Senonian of Villedieu. A, B, C, and D from Cotteau Collection; E from Lambert Collection.

*Holotype.* Specimen (not seen) represented by cast T 49 in the Agassiz and Desor Collection (Université de Neuchâtel). Stated to be from the Turonian of Touraine by Lambert and Jeannet (1928).

*Description.* Small to medium sized species (30–45 mm long). In the anterior paired petals the pores of rows IIa and IVb are usually more elongate than those of IIb and IVa, and thus give rise to broader poriferous zones. Pore pairs of the unpaired petal are not at right angles to the edge of the petal but are in the form of 'V's pointing towards the apical system. At the ends of the paired petals (in positions where a peripetalous fasciole is to be found on certain spatangoids) are areas in which tubercles are more or less absent and the granules smaller and more tightly packed than is usual in this region, giving a smooth appearance in comparison with the rest of the upper surface of the test. The sub-anal fasciole is very variable in its development, often incomplete and diffuse.

*Range.* Upper Cenomanian and Turonian.

*Epiaster laxoporus* (d'Orbigny), 1855

Plate 109, figs. 7–9; text-fig. 1c–e

With the exception of Rowe's specimen from Dover, post-Turonian Epiasters are known only from Touraine and Aquitaine. The ranges of such forms are given from these latter regions (Stokes 1975, figs. 17 and 18) using the trivial names adopted by Lambert (1895) and stratigraphical information in de Grossouvre (1897–1898).

Senonian species of *Epiaster* (previously attributed to *Micraster laxoporus* d'Orbigny, 1855, *M. latiporus* Cotteau, 1869, *M. carentonensis* Lambert, 1895, and Lambert's variety *campaniensis* (1895) of *M. laxoporus*) have been distinguished from each other by such characters as: the number of pairs of pores in the paired petals; the size; the position of the apical system; the development of the heel; the depth of excavation, the length and the flexuosity of the paired petals. From the limited quantitative information given in Lambert (1895) and the few specimens available for study, the author is not convinced that differences between the Senonian species would stand up to statistical treatment if sufficient material were available for such a study. In this paper, therefore, the oldest available name (*E. laxoporus*) has been used for all post-Turonian Epiasters.

The author has been able to examine in detail only four well-preserved Senonian Epiasters, all of which come from the Coniacian Craie de Villedieu of Touraine, France: one from Couture and one from Torchay (Lambert Collection both numbered 538 and labelled *M. carentonensis*), and two from 'Villedieu' (Cotteau Collection both labelled *M. laxoporus*). Of the several characters measured and counted, only the relative length of the anterior paired petals could be used to distinguish these specimens from *E. michelini*. In the latter species the length of the anterior paired petals is over 30% of the length of the test (four specimens: 30.2, 30.3, 31.4, and 33.8%) whereas in the Senonian species these petals are shorter and do not reach 30% of the length of the test (four specimens: 25.3, 26.1, 27.7, and 29.2%). The length of the test was measured, using external calipers, from the most anterior part of the test to the most posterior point above the periproct; the length of the right anterior paired petal was measured, using internal calipers under a binocular microscope,

from the contact with the ocular plate to the adoral suture of the farthest plate bearing enlarged pores.

*Range.* Coniacian to Lower Maastrichtian.

#### MICRASTER Agassiz, 1836

*Type species.* *Micraster coranguinum* (Leske, 1778), by the subsequent designation of Pomel (1883).

The numerous evolutionary trends to which *Micraster* was prone (Stokes 1975, pp. 81–84) make a succinct diagnosis of this genus almost impossible. The test is thick (1–2 mm), except in *M. corbovis* whose test is thin as in *Epiaster*; the depth of the anterior notch is very variable; the peristome may be one-third of the total length from the anterior border, marginal, or any where in between these extremes; the labrum may be feebly projecting to strongly projecting such that it completely covers the peristome; the number of interambulacra joining the peristomal margin is variable; paired petals vary from deeply sunken to superficial, their pores are conjugate with the outer rows elongate and the inner rows typically round; interporiferous zones of the paired petals vary from smooth to divided; pores of the unpaired petal usually round, those of one pair being separated by granules, but sometimes developed like those of the paired petals; the number of ocular plates touching the madreporite varies from two to five; the periproct is usually round, situated at a very variable height from the base of the test; plastronal tubercles often tightly packed together; periplastronal areas varying from fine to coarsely granular, sometimes with tubercles present; a distinct sub-anal fasciole is usually present but this may be absent and a supplementary peripetalous fasciole may be incompletely developed.

*Range.* Middle Turonian to Lower Maastrichtian.

#### *Micraster coranguinum* (Leske), 1778

Figured as *M. coranguinum* by Chatwin 1924, pl. 2, figs. 4, 5, 10.

Although variable in form and size, this species is typified by: a sharp groove which runs down the mid-line of each paired petal ('interporiferous zones divided'); coarsely granulated periplastronal areas; an anterior notch which is deeper than in *M. decipiens*; the whole peristome being hidden by the labrum when the echinoid is viewed from below; the peristome being closer to the anterior border than in *M. decipiens*.

*Range.* *coranguinum* Zone to *pilula* Zone (*M. coranguinum* s.l.), *coranguinum* Zone to *Marsupites* Zone (*M. coranguinum* s.s.).

#### *Micraster coranguinum rostratus* (Mantell), 1822

Plate 108, figs. 4–6

The distinctive features of this subspecies are: adults are usually 50–70 mm in length; a subconical shape; a strongly arched carina which overhangs the low periproct; pores of the unpaired petal tend to become conjugate; pores of the paired petals more numerous than in *M. coranguinum* s.s.

*Range.* *Marsupites* Zone.

*Micraster coranguinum simpsoni* Stokes, 1975

Plate 109, figs. 4-6

This broad and low subspecies is usually 45-50 mm in length and is typified by: a test somewhat thinner than that of *M. coranguinum* s.s.; a long and narrow labral plate; a gently curved carina which overhangs the periproct; areas between the pore zones of the paired petals which have lost the distinctive mid-line groove characteristic of *M. coranguinum* s.s.

*Range.* Marsupites Zone and pilula Zone.

*Micraster corbovis* Forbes, 1850

All specimens of this species have: a thin test, usually about 0.5 mm thick; relatively short paired petals whose areas between the pore zones are smooth; the peristome relatively far from the anterior border and lacking a projecting labrum.

*Range.* lata Zone and planus Zone.

The planus Zone form of *Micraster corbovis*

Plate 106, figs. 1-3

This rare form, which is represented by the type specimen, is distinguished by: its large size, being up to 80 mm in length; its swollen aspect.

The lata Zone form of *Micraster corbovis*

Plate 106, figs. 4-6

This form is less rare than that of the planus Zone and is typified by: a side profile which shows that the maximum height is close to the anterior; its small size which rarely exceeds 50 mm in length; its steep anterior slope and gentle posterior slope of the upper surface when viewed in profile.

*Micraster decipiens* (Bayle), 1878

Plate 108, figs. 1-3

This is the species which has usually been called *M. cortestudinarium* and it is distinguished by: a very rounded outline when viewed from above or below; the groove

## EXPLANATION OF PLATE 106

Figs. 1-3. *Micraster corbovis* Forbes. The type specimen from Sussex representing the planus Zone form of the species. Oral, apical, and left lateral views. BM(NH) E 30157,  $\times 1$ .

Figs. 4-6. *Micraster corbovis* Forbes. The lata Zone form of the species. 4 and 5, oral and apical views of a specimen from the planus Zone (*sensu* Rowe) of Dover, Rowe Collection, BM(NH) E 37706. 6, right lateral view of a specimen from the lata Zone of Dover, Rowe Collection, BM(NH) E 37695,  $\times 1$ .



STOKES, *Micraster corbovis*

which runs down the mid-line of the paired petals is broader and less sharp than in *M. coranguinum* ('interporiferous zones subdivided'); when viewed in profile the upper surface is rather symmetrically arched; the peristome is further from the anterior border than in *M. coranguinum*, and it is not completely hidden by the labrum when viewed from below.

*Range.* *normanniae* Zone to basal part of *coranguinum* Zone.

*Micraster gibbus* (Lamarck), 1816

Figured as *M. (Isomicraster) senonensis* by Kermack 1954, pls. 24-26, figs. 13, 15, 17.

This uncommon species is distinguished by: a conical shape; a low periproct, situated between 45 and 56% of the total height; a tendency in the unpaired petal for there to be a groove between the pores in each pair ('conjugate pores'), i.e. the unpaired petal is like the paired petals; a reduction or absence of the sub-anal fasciole.

*Range.* *decipiens* Zone and *coranguinum* Zone.

*Micraster leskei* (Des Moulins), 1837

Plate 108, figs. 7-9

Typical specimens of this species are: small, not often exceeding 40 mm in length; relatively narrow, but high compared with *M. normanniae*; lacking a groove along the mid-line of the petals, but under a hand-lens the sutures between the ambulacral plates are visible; having a peristome about a quarter to a third of the length from the anterior border, and a feebly developed labrum.

*Range.* *planus* Zone.

*Micraster normanniae* Bucaille, 1883

Plate 107, figs. 1-3, 7-9

The distinguishing features of this rare species are: when viewed from above the maximum breadth is close to the anterior; the side profile is markedly flat and low; the paired petals are relatively short.

*Range.* Upper part of *planus* Zone and *normanniae* Zone.

EXPLANATION OF PLATE 107

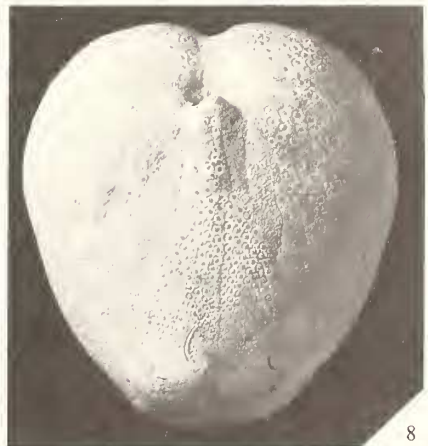
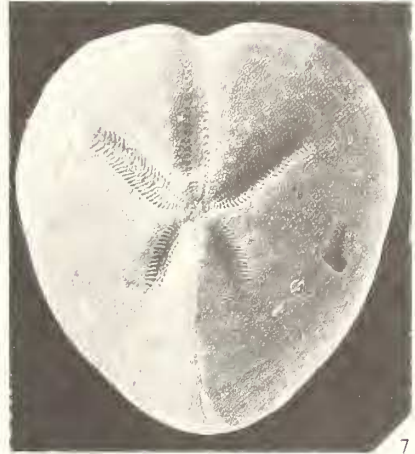
Figs. 1-3. *Micraster normanniae* Bucaille. Apical, oral, and left lateral views of a specimen from the base of the *cortestudinarium* Zone of Dover, between two strong flint lines 15 ft (4.57 m) apart (Rowe's MS. label). Rowe Collection, BM(NH) E 38020,  $\times 1$ .

Figs. 4-6. *Epiaster michelini* (Agassiz). Apical, oral, and left lateral views of a specimen from 0.2 m below the Chalk Rock, Kensworth, Herts., author's collection No. 2360,  $\times 1$ .

Figs. 7-9. *Micraster normanniae* Bucaille. Apical, oral, and left lateral views of the type specimen from the 'lit tubulé' in the cliffs at Pollet, Seine Maritime, France. Bucaille Collection, Muséum d'Histoire naturelle de Rouen,  $\times 1$ .

Figs. 10 and 11. *Epiaster michelini* (Agassiz). Apical and right lateral views of a plaster cast of the type specimen from the Turonian of Touraine. Cast T 49, Agassiz and Desor Collection, Université de Neuchâtel,  $\times 1$ .





*Micraster westlakei* Stokes, 1975

Plate 109, figs. 1-3

This rare species, which resembles *M. coranguinum*, is distinguished by: its large size, being 60-70 mm in length; the strong curve of the carina when viewed in profile; a relatively low periproct; an almost marginal peristome covered by a strongly projecting labrum.

*Range.* *mucronata* Zone.

Rowe introduced the name *Micraster praecursor* (without designating a type specimen) for a range of *Micraster* which had in common only a breadth less than length, and decoration which Rowe collectively described as 'low-zonal'. Under *M. praecursor* he included forms here separated into *M. decipiens*, *M. normanniae*, and large forms of *M. leskei*, together with a variety of other species which have never been found in England. For these reasons the name is abandoned.

THE TURONIAN AND SENONIAN SPATANGOID SUCCESSION IN  
SOUTHERN ENGLAND

Definitions of certain zonal boundaries are given in the section on Chalk stratigraphy.

*Epiaster* occurs in the *labiatus* Zone at Seaton, Devon. The specimen (Wright's Collection) recorded by Kermack (1954) as *M. leskei*, is an *Epiaster*. Likewise, all the specimens in Rowe's Collection from the south Devon 'Cuvieri Zone', which he called *M. corbovis*, are *Epiaster*. Specimens of *Epiaster* from the *lata* Zone were collected by Rowe from the Hooken-White Cliff region, South Down Common, and Compton Bay. From the *planus* Zone Rowe collected specimens from Pinhay Bay, Westerham, and east of Dover. In Mr. Wood's Dover collection it can be seen that the *Epiaster* stock ranges up into the lower part of the Chalk Rock where it occurs with intermediates to *M. leskei*. Above the Chalk Rock the only known specimen of *Epiaster* is an *E. cf. laxoporus* in the Rowe Collection recorded as *M. corbovis* from 6 m above the base of the Cortestudinarium Zone (Rowe 1899).

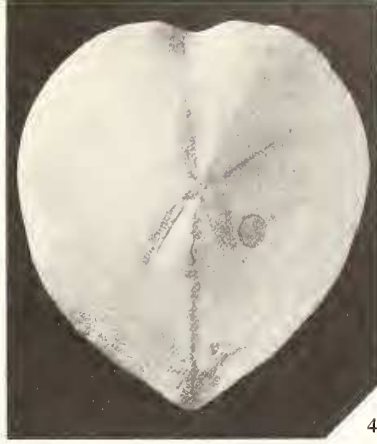
The *lata* Zone form of *M. corbovis* is not common and does not range as high as the Chalk Rock in Wood's Dover material. The author has not seen any specimens of the *planus* Zone form of *M. corbovis* which have been collected bed by bed.

*M. leskei* first appears in the Chalk Rock. The author has found only the typical small form in the lowest Chalk Rock hardground at Kensworth, Herts., which is immediately followed by an horizon yielding fragments of a very large *Micraster*.

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EXPLANATION OF PLATE 108

- Figs. 1-3. *Micraster decipiens* (Bayle). Apical, oral, and left lateral views of a specimen from Purley, Surrey. T. Wright Collection, BM(NH) E 1512,  $\times 1$ .
- Figs. 4-6. *Micraster coranguinum rostratus* (Mantell). Apical, oral, and right lateral views of the type specimen from the Chalk near Brighton. Mantell Collection, BM(NH) E 8662,  $\times 1$ .
- Figs. 7-9. *Micraster leskei* (Desmoulins). Apical, oral, and left lateral views of a specimen from the Chalk Rock of Dover. J. D. Hollis Collection,  $\times 1$ .



From a second hardground, 0.7 m above the first, I have collected a distinctive medium-sized variety of *M. leskei*.

Intermediates between *E. michelini* and *M. leskei* occur in the Wood Collection from the Chalk Rock, but typical specimens of the latter are lacking. In the lower part of the Chalk Rock at Dover large forms of *M. leskei* have already appeared.

Many of the *Micraster* from the mass of the *planus* Zone, which many authors may call *M. corbovis* and/or *M. praecursor*, are here included amongst large forms of *M. leskei*. Intermediates between *M. leskei* and *M. normanniae* occur throughout the *planus* Zone above the Chalk Rock. Whilst the typical form of *M. normanniae* is found within the 1.5 m of chalk above the Top Rock, early specimens of this species appear in the upper 1.5 m of the *planus* Zone.

The commonest *Micraster* of the old 'Cortestudinarium Zone' is *M. decipiens*. The earlier ones, from the *normanniae* Zone and the lower half of the *decipiens* Zone, are not as rounded in outline as the higher ones seen which are closer to the type. Many of the large *M. leskei* from the upper part of the *planus* Zone have features which indicate that they are transitional to *M. decipiens*.

The earliest specimen of *M. gibbus* known to the author is that collected by Mr. Wood some 4.5 m above the Top Rock at Dover. The latest occurrence of this species seems to be in the Barrois Sponge Bed on Thanet. In the *coranguinum* Zone intermediates between *M. gibbus* and *M. coranguinum* occur. This pair of sympatric species and its intermediates has been discussed by Kermack (1954) and Stokes (1976).

*M. coranguinum*, from Wood's Dover material, first appears between two marl seams which are respectively 18 and 20 m above the Top Rock. *M. decipiens* is still present at this horizon, and indeterminate specimens of *Micraster* occur in the 9 m of chalk above the lower of the two marls.

Throughout much of its zone, *M. coranguinum* is not particularly common and bed by bed collections are lacking. The species becomes relatively abundant from Whitaker's '3-inch' Band to 1.5 m above the Barrois Sponge Bed on the Thanet coast. From museum material it is seen that advanced forms of *M. coranguinum* continue into the *Marsupites* Zone.

A broad flat *Micraster* collected by the author from the Barrois Sponge Bed is indistinguishable from *M. rogalae* of the Northern Faunal Province (see Kermack 1954 and Stokes 1975), and may thus indicate either a migration of northern elements or homoeomorphy.

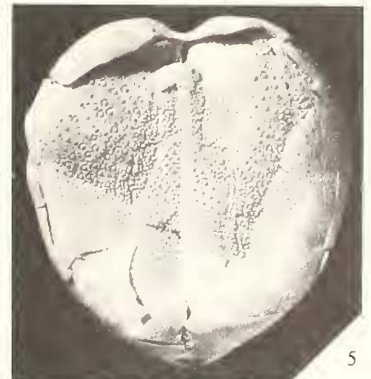
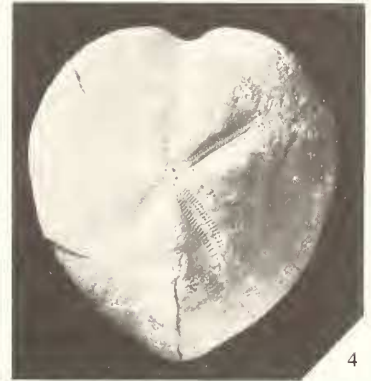
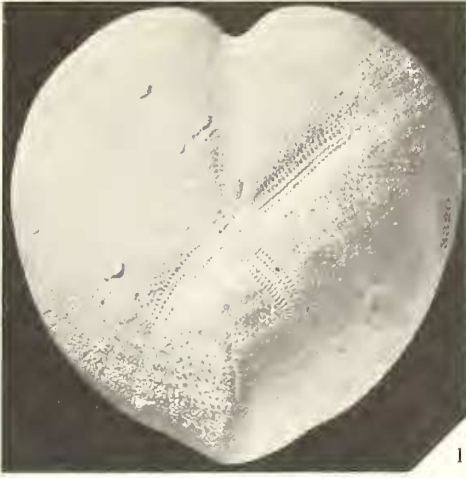
*M. coranguinum rostratus* is known to the author only from museum material of which the horizon is simply stated to be the *Marsupites* Zone.

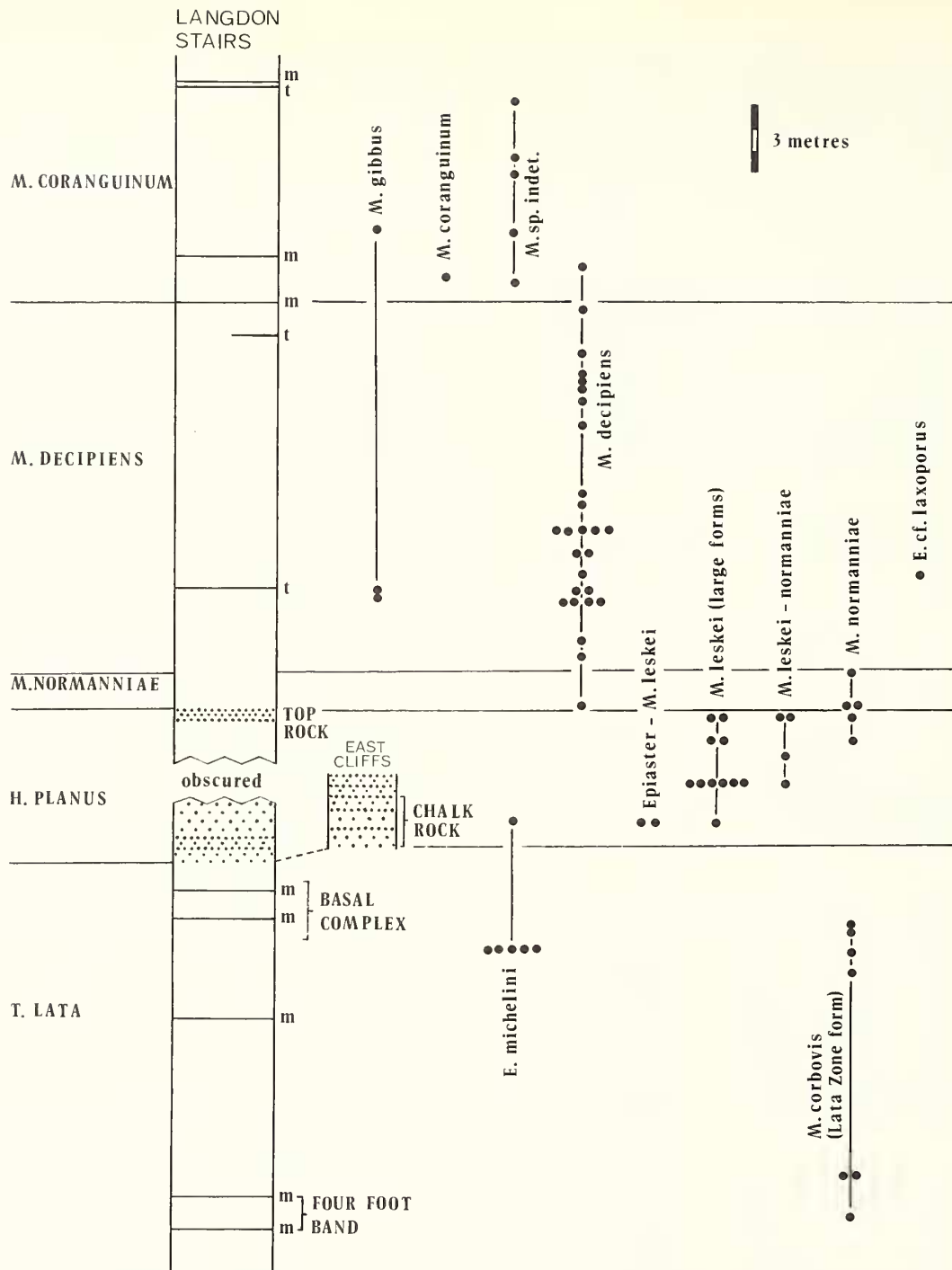
#### EXPLANATION OF PLATE 109

Figs. 1-3. *Micraster westlakei* Stokes. Figs. 1 and 2, apical and right lateral views of the type specimen No. 3320,  $\times 1$ . Fig. 3, oral view of specimen No. 3321. Both specimens from the *mucronata* Zone, Tichbourne Farm, Hants. Westlake Collection, University of Southampton,  $\times 1$ .

Figs. 4-6. *Micraster coranguinum simpsoni* Stokes. Apical, oral, and left lateral views of the type specimen from the *tectiformis* horizon of the *pilula* Zone, Saltdean, Sussex. R. Simpson Collection S54,  $\times 1$ .

Figs. 7-9. *Epiaster laxoporus* (d'Orbigny). Oral, apical, and left lateral views of a specimen from the Craie de Villedieu (Coniacian), Villedieu, Loir et Cher, France. Cotteau Collection, Université d'Orsay,  $\times 1$ .





TEXT-FIG. 2. Stratigraphical distribution of spatangoids in the Dover cliffs. *m* = marl band; *t* = tabular flint band; stipples = important hardground; each spot represents one specimen. With the exception of *E. cf. laxoporus*, which is from the Rowe Collection, all specimens are from the C. J. Wood Collection. The section was measured at Langdon Stairs (TR 346 425) and Mr. Wood indicated the horizons from which his specimens were collected. See text for definitions of zonal boundaries.

*Micraster coranguinum simpsoni* first appears in the Marsupites Zone. Mr. Simpson has collected it from the upper part of this zone at Friars Bay, Sussex, and the author has collected a loose specimen from the cliffs at Cliftonville near Margate where only the Marsupites Zone is exposed. In the lower part of the *pilula* Zone the subspecies is common at Saltdean. *Micraster* is apparently absent from the remainder of the Lower Campanian in southern England.

*M. westlakei* is known from only three specimens in the Westlake Collection, all coming from the *mucronata* Zone of Tichbourne Farm, Hants. From this pit Mr. Hollis collected a small conical *Echinocorys* which is here interpreted as indicating an horizon low in the *mucronata* Zone.

*Micraster* is quite common in the *mucronata* Zone at Studland Bay, but the crushed and fragmentary material collected there by the author cannot be identified.

Kermack (1954) recorded a very large *Micraster glyphus* in the Hawkins Collection from the *mucronata* Zone of the Isle of Wight. Assuming this identification to be correct, the specimen indicates a southern migration of the Northern Faunal Province stock.

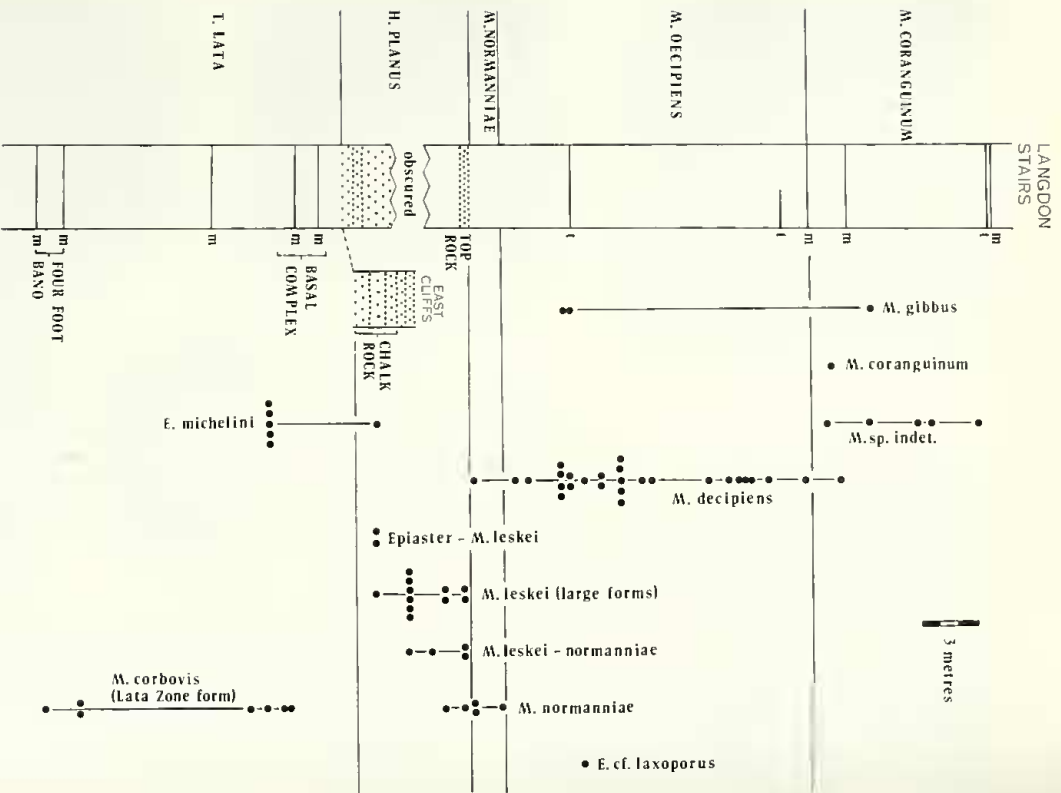
#### IMPLICATIONS FOR CHALK STRATIGRAPHY OF THE DOVER SPATANGOID SEQUENCE

The *lata-planus* Zone boundary has been drawn at various horizons. Rowe (1900) placed it at a marl band 2.9 m below the base of the Chalk Rock on the grounds that it was at this level that one first finds an association of *Holaster planus*, *Micraster*, and *Echinocorys*. Rowe did not state which species of *Micraster* he found, and a perusal of his faunal records in the *lata* Zone suggests that it was the appearance of *Echinocorys* that was the deciding factor. Numerous records of *Echinocorys* in the *lata* Zone (Hayward 1940) show that such a definition is unacceptable. On the spatangoid faunas it would be more sensible to place the zonal boundary at the base of the Chalk Rock in which we see the appearance of large forms of *M. leskei* and transitions between *E. michelini* and *M. leskei*. In other localities typical small *M. leskei* appear within the Chalk Rock.

*The planus-cortestudinarium* Zone boundary. It is now difficult to decide from Rowe's description which horizon he took for this boundary, but he said that it coincided with the disappearance of *Holaster planus* itself, *M. corbovis*, and *M. leskei*. This is generally held to correspond to the upper limit of the Top Rock.

*M. decipiens* predominates in the chalk above the Top Rock and ought to give its name to this zone, following de Grossouvre's (1895-1896) reference to this part of the English succession as the 'Craie à *Micraster decipiens*'.

The 1.5 m of chalk above the Top Rock at Dover yield *M. normanniae* and would be regarded as a separate *normanniae* Zone, between the *planus* and *decipiens* Zones, on the Normandy coast (Cayeux 1967). In view of the fact that Mr. C. W. Wright has collected Turonian ammonites from the lower part of the *cortestudinarium* Zone (pers. comm. 1968), and that a comparison of the spatangoid faunas of the north-west and south-east of the Paris Basin suggests that the *normanniae* Zone is Turonian (Stokes 1975), it seems desirable to admit a *normanniae* Zone in southern England.



TEXT-FIG. 2. Stratigraphical distribution of sputangoids in the Dover cliffs. *m* = marl band; *l* = tabular flint band; stipples = important hardground; each spot represents one specimen. With the exception of *E. cf. laxoporus*, which is from the Rowe Collection, all specimens are from the C. J. Wood Collection. The section was measured at Langdon Stairs (TR 346 425) and Mr. Wood indicated the horizons from which his specimens were collected. See text for definitions of zonal boundaries.



